Modelling dependent effect sizes in meta-analysis: Possibilities and limitations of three-level models

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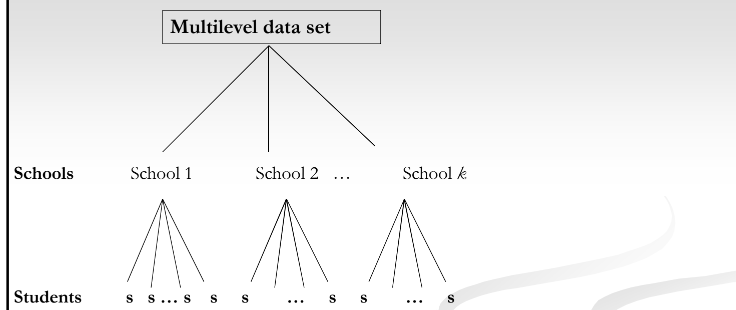
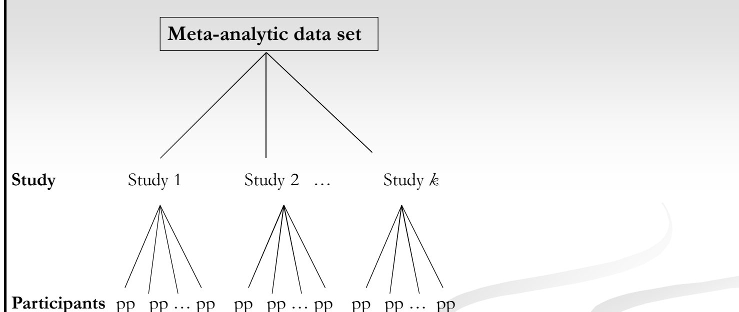
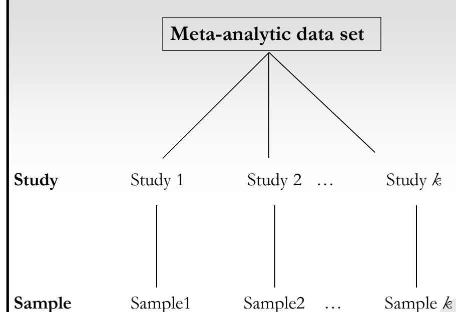
4th European Congress of Methodology

Potsdam, July 21-23, 2010







- mean?

- variance?
- study characteristics?

$$\sigma^2_{d_j} \cong \frac{n_E + n_C}{n_E n_C} + \frac{\delta_j^2}{2(n_E + n_C)}$$

Example 1: Mechanisms of masked priming: A meta-analysis

Van den Bussche, E., Van den Noortgate, W., & Reynvoet B. (Psychological Bulletin, 2009)

→ 23 studies, 88 experiments

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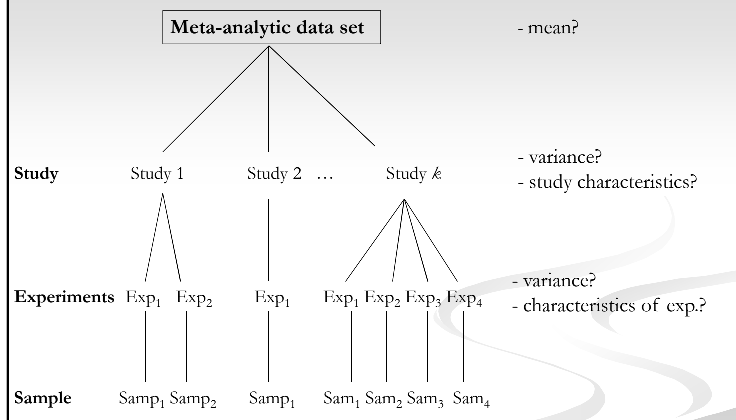

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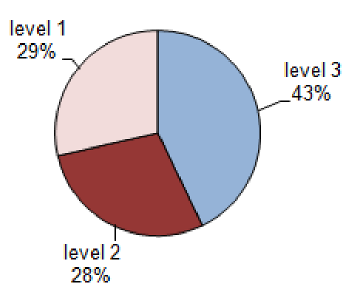
Random Effects Model



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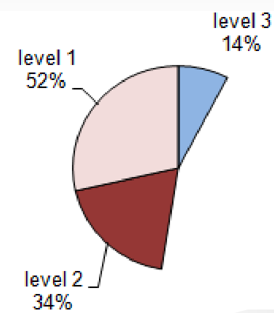
Mixed Effects Model



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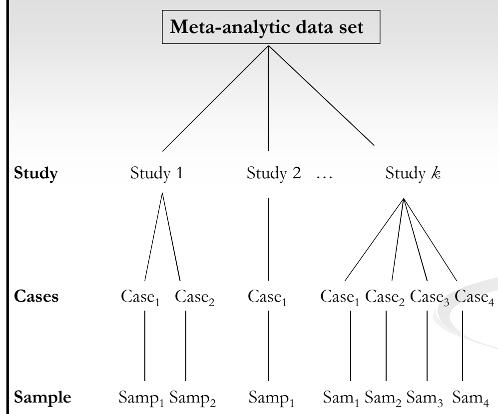
Example 2: The effect of choice-making as an intervention for problem behavior: A meta-analysis

Van den Noortgate & Onghena (2009). *Evidence-Based Communication Assessment and Interventions*

Reanalysis of

Shogren, K.A. et al. (2004), *Journal of Positive Behavior Interventions*

→ 13 single-case studies, 31 cases



- mean?

- variance?
- study characteristics?

- variance?
- Case characteristics?

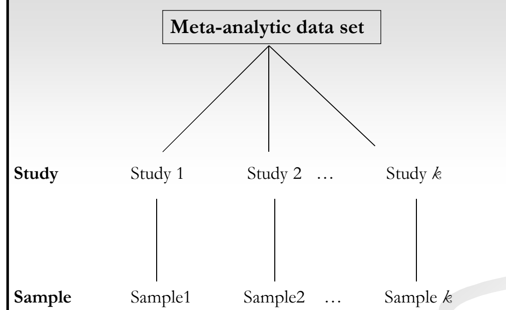
Fixed	
Intercept	1.72 (0.35)
Variances	
Level 3:	0.51 (0.81)
Level 2:	2.11 (0.79)
Level 1:	0.19

Fixed		
Intercept	1.72 (0.35)	1.60 (0.63)
Male		0.09 (0.67)
Choice		0.22 (0.85)
Variances		
Level 3:	0.51 (0.81)	0.60 (0.97)
Level 2:	2.11 (0.79)	2.23 (0.87)
Level 1:	0.19	0.19

But …

independent samples assumed!

What if multiple outcomes?



$$\sigma^2_{d_j} \cong \frac{n_E+n_C}{n_E n_C} + \frac{\delta_j^2}{2(n_E+n_C)}$$

$$\sigma_{d_j d_{j'}} \cong \frac{n_E+n_C}{n_E n_C}\rho_{jj'} + \frac{\delta_j \delta_{j'} \rho^2_{jj'}}{2(n_E+n_C)}$$

Dealing with sample dependencies

- Perform a multivariate meta-analysis

But: where do we get the correlations?

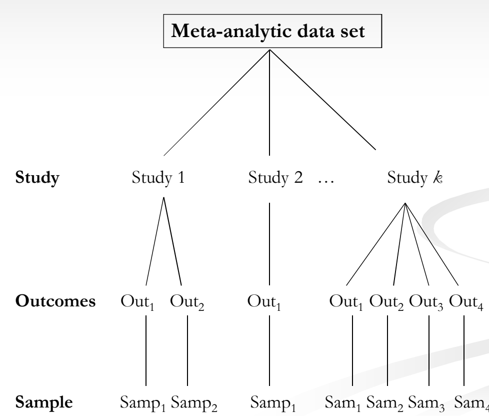
- Ignoring dependencies

But: overusing information

- Randomly choose one effect size per study
- Average effect sizes per study
- Choose the most relevant outcome per study
- Do separate meta-analyses

But: loss of information

What about using a three level model?



Simulation design

- Raw data generated
- Multivariate (2 outcome variables) 2-level model
- Variance within samples: 1
- Covariance within samples: 0, .4 and .8
- Variance between studies: .1, .2
- Covariance between studies: .5
- Mean effect: 0, .25, .50
- N = 30, 80; k= 40, 80

→ 72 x 1000 datasets

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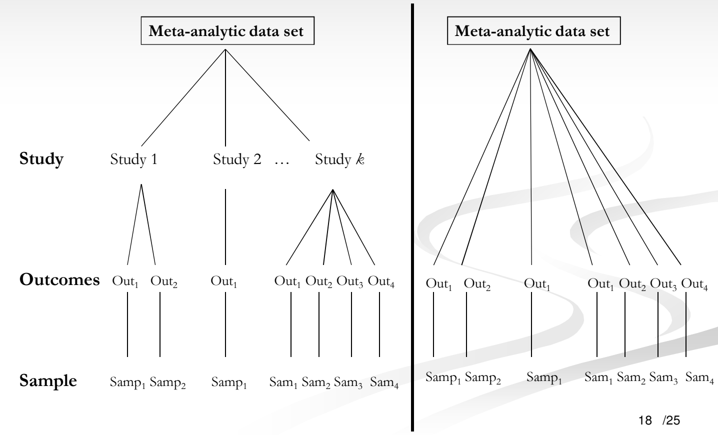
Analysis



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Results

- Mean effect almost unbiased
- SE of mean effect

(for effect = 0, n=30, k=80; but same pattern for other combinations)

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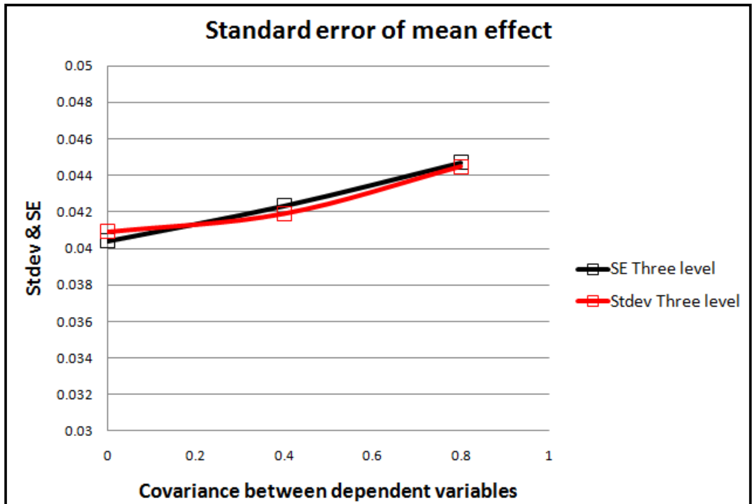

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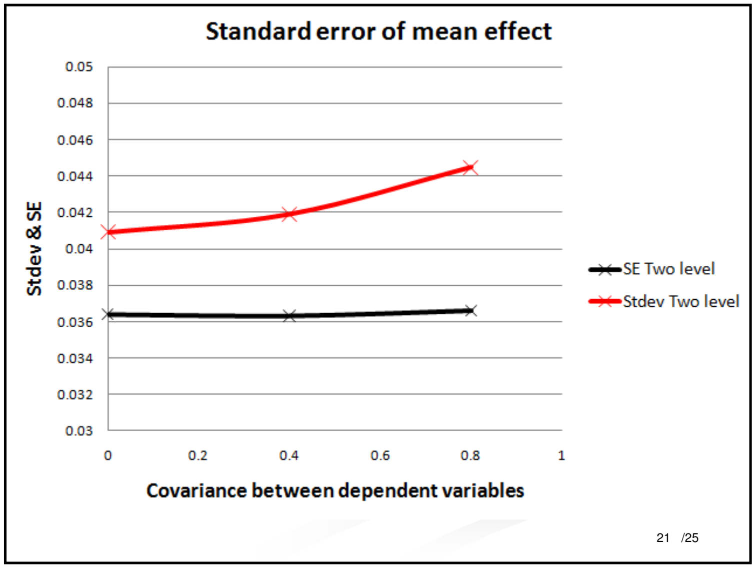
Standard error of mean effect
Stdev & SE
0.05
0.048
0.046
0.044
0.042
0.04
0.038
0.036
0.034
0.032
0.03
0
0.2
0.4
0.6
0.8
1
Covariance between dependent variables
SE Two level
Stdev Two level
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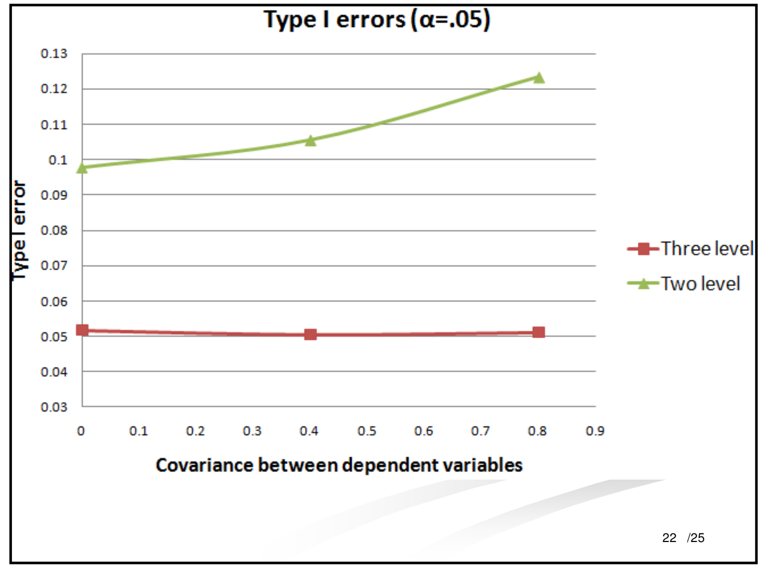
Type I errors (α=.05)
Type I error
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Covariance between dependent variables
Three level
Two level
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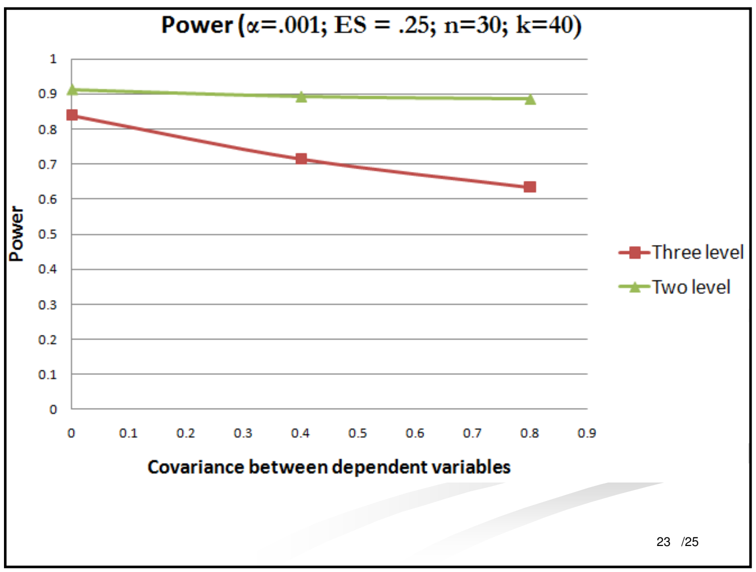
Power (α=.001; ES = .25; n=30; k=40)
Power
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Covariance between dependent variables
Three level
Two level
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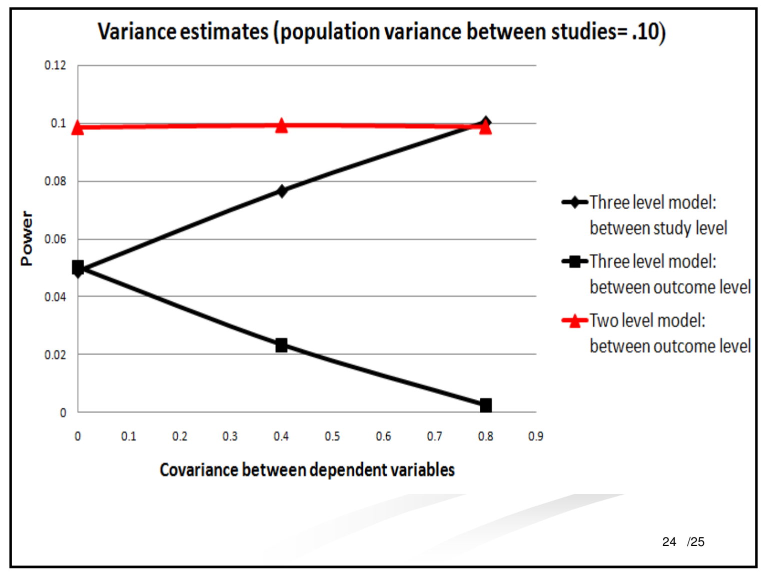
Variance estimates (population variance between studies= .10)
Power
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Covariance between dependent variables
Three level model: between study level
Three level model: between outcome level
Two level model: between outcome level
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Conclusion

- ML-MA elegant way to account for dependencies between effect sizes based on independent samples
- Promising results for ML-MA for dependencies due to dependent samples!
- More simulation (& analytical work) needed and currently being done

Thank you!

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Van den Bussche, E., Van den Noortgate, W., Reynvoet, B. (2009). Mechanisms of masked priming: A meta-analysis. *Psychological bulletin, 135*, 452-477.

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